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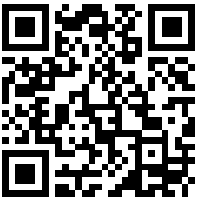

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SCIENCE AND PROGRESS IN THE INDUSTRIES

JOHN J. CARTY

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SCIENCE AND PROGRESS IN THE INDUSTRIES[1]

JOHN J. CARTY

On this occasion which marks the semi-centennial of the incandescent electric light, it is my privilege to address the National Electric Light Association on the subject of "Science and Progress in the Industries."

The unparalleled advances which have been made by the members of this Association, in extending the benefits of light and power even to the most remote hamlets of the land, are due to many causes, scientific, economic, and administrative. You have made enduring contributions to the economic welfare of the country, contributions destined as time goes on to bring about in our social and industrial life still greater improvements, the nature of which we can as yet only dimly perceive. Fifty years ago, service such as you are now rendering to the public was unknown; it did not then even exist. But today this service which you have organized is so vital that without it the present industrial structure itself could not exist. Behind all of this lies a story of American enterprise, of administrative capacity, and of a public service effectively rendered, which is worthy of the admiration of all.

The historian of the future, writing with that perspective and with that detached state of mind which comes with the lapse of time, will find in the achievements of the members of this Association material for one of the most interesting chapters in the history of American industry. While he will justly appraise the effectiveness of your organization, and the spirit of service which actuates your employees, he will show much better than can now be done how dependent is progress in your industry upon the advancement of science.

It has been said that next to the verdict of history, the observations of foreign contemporaries are calculated to give a trustworthy estimate of the achievements, the progress, and status of a nation. There may be enough truth in this to afford some measure of justification for me, as an engineer outside of the electric light and power industry, in venturing to discuss some of the relations of science to the remarkable progress which you have made. I shall speak, therefore, as one interested in the advancement of science but detached from your activities—commenting as an observer who has followed attentively the progress which you have made in your industry from the time of its inception.

One of the outstanding factors in the success of the electric light and power industry is its encouragement and support of laboratories for re-

[1] An address delivered before the National Electric Light Association Convention, June 5, 1929.

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search in applied science. In the operation of these laboratories, millions of dollars are expended each year, and thousands of men are employed, including engineers and scientists distinguished for their achievements in so many departments, including physics and chemistry. They have perfected generators, motors, transformers, and prime movers. They have made contributions to transportation, commerce, and industry. They have provided agencies for the advancement of medicine and surgery, and they have contributed in countless ways to the social welfare. Every individual, whether on the farm or in the office or workshop, whether at home or in a hospital or at church or in the theatre, is receiving the benefits of these achivements. Whether traveling on land or by sea or in the air, our safety and comfort and ease of transport are dependent far more than is yet realized upon the work of your industrial scientists. Volumes would be required to show how their manifold products have transformed and enriched our daily lives.

But let me give a specific illustration which seems to be in a special manner appropriate on this occasion which marks the semi-centennial of the incandescent electric light, the invention of our great scientist and inventor, Thomas A. Edison. Let us go back only to the year 1907, which marks the introduction of the metallic filament lamp, and consider some of the progress which has been made in the electric lamp since that date.

By the year 1907, the improved carbon lamp, as the result of incessant scientific experimentation, had reached an efficiency giving an illuminating power of about 3 lumens (3.4) for each watt of energy employed. In that year, 1907, and as the result of profound research conducted by distinguished scientists in your industrial laboratories, a great forward step was taken in the introduction of the metallic filament lamp, which rapidly displaced even the best of the carbon lamps.

The tungsten filament lamp of 1928 which is the one now in general use, yields more than 14 lumens (14.5) per watt of energy. Thus it is more than 4 times (4.26) as efficient as the best carbon lamp of 1907, assuming in the comparison the same average size and the same hours of life.

Trustworthy figures show that in the United States alone, during the year 1928, the total expenditure by the public for lighting by means of the incandescent lamp was, in round figures, $600,000,000. If it had been necessary to provide that same amount of illumination by means of the best carbon light of 1907, then more than 4 times (4.26) as much electrical energy would have been required, and the bill for lighting which the public would then have had to pay would have been multiplied ac-

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cordingly. The $600,000,000 would become $2,556,000,000. Were it not for the reduction in the cost in the generation and distribution of electric current which you have brought about since 1907, this figure would have to be increased by $300,000,000. From this it will be seen that the total reduction due to these items alone, is now well over two billion dollars a year ($2,256,000,000).

This sum, almost incredible in amount, represents a cost reduction brought about by one of the products of the electric light and power laboratories—the modern tungsten filament lamp—and by the improved methods of generating and distributing current which your scientists have developed. Even though no further improvements should be made, these figures will grow larger each year. Yet they take no account of the savings due to the prices at which incandescent electric lamps and electrical machinery are now sold when compared with the prices of twenty-five years ago. Nor do they include any appraisal of the contributions which your industrial scientific research has made to the present unexampled prosperity of the American industries.

These figures furnish the simplest method of emphasizing the progress which science has made in your industry in the generation and distribution of electric light and power. But taken alone they do not tell the whole story, for upon reflection it will be seen that without these reductions in cost a large proportion of the public now enjoying the benefits of light and power would be wholly deprived of the advantages which they now derive from your service. The remainder of the public which would still be carried on your books as customers, could not afford to use the electric current in such large quantities as they now do, nor to employ it in such a great variety of useful and profitable ways.

The slowing down of the industrial and other activities of the country which would have resulted from such a curtailment in electric service, would connote an economic loss which it is impossible to state in pecuniary terms. Whatever it may be, the sum which represents the debt of society to your industrial scientific laboratories must be so large as to be almost incredible.

In endeavoring to appraise the value to the public of research in applied science conducted by your industry, I have employed a method which I have used in estimating in pecuniary terms the value to the public of applied science in the telephone art. On previous occasions I have given the results of these estimates, so that at this time I will only say that there, likewise, I have found that as a result of the scientific researches in the company laboratories, sums of money similarly great have been saved to the telephone users; and at the same time the service has

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been constantly improved, and extended into every section of our country, and across the ocean, even now rapidly bringing the nations of the earth into speaking communication with each other.

Let me pause for a moment to mention the name of Alexander Graham Bell, the inventor of the telephone. It is only a few years since he passed away. If he were still alive, we can feel sure that he would be here upon this occasion to pay tribute to his friend and fellow-citizen, Thomas A. Edison, the inventor of the incandescent light, who is also the inventor of the carbon telephone transmitter, and the inventor of the phonograph. This unites his name in an especial manner with that of Bell. The one revealed the method of transmitting the human voice through the vastness of space, and the other, through the ages of time. As a long-time friend of Mr. Edison, and as one who so greatly admires his genius, I wish that I could adequately express my appreciation of his achievements. This I could hope to do if I could speak in the eloquent language that Bell himself would use. But it is not within my power to put in words the message which one of these immortals would give to the other. It gives me great satisfaction to be able to join with so many millions of others in honoring Mr. Edison and adding to their's my own congratulations and felicitations.

The scientific industrial research conducted in your laboratories is often called "research in applied science." Applied science must submit its findings to the criterion of utility. It must produce practical results, things that can be used with advantage, perform new services, or bring about new economies. It must continue to pay for itself and yield a profit. Otherwise it must cease. The figures which I have presented and the evidence which I have submitted, abundantly prove the extraordinary value of the researches conducted in your laboratories. Your applied science does pay for itself, and more. Your industry could not exist without it. You cannot allow it to cease, and you will continue to prosecute it with ever-increasing success.

But I have already said so much, and there is so much more that could be said, showing the importance of scientific research conducted for the sake of utility and economy, that there is danger of losing sight of another form of scientific research which has for its primary object neither of these things. I refer to scientific research conducted purely for the sake of extending the boundaries of knowledge, discovering the laws by which nature operates, and determining the principles of mathematics, astronomy, biology, chemistry, and physics.

Pure scientific research is conducted with a philosophic purpose, for the discovery of truth and for the advancement of learning. Investiga-

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tors in pure science may be likened to explorers who discover new continents or islands, or hitherto unknown territory. They are continually seeking to push forward the frontiers of knowledge. Their work is conducted without any utilitarian motive, for as Huxley says "that which stirs their pulses is the love of knowledge and the joy of discovery of the causes of things . . . the supreme delight of extending the realm of law and order ever farther toward the unattainable goals of the infinitely great and the infinitely small, between which our little race of life is run."

The pure scientists are the advance guard of civilization. By their discoveries they furnish to the engineer and the industrial chemist and the other applied scientists the raw materials to be elaborated into manifold agencies for the amelioration of the condition of mankind.

Let me illustrate this by the work of Scheele, a Swedish scientist, who in 1781 made a fundamental discovery respecting tungstic acid. He furnishes a classic example of the motive and achievements of the investigator in pure science. Aside from his pioneer work in tungsten, independently of Priestley he discovered oxygen. He also discovered manganese, chlorine, barium, and molybdenum. Truth, not utility, was his criterion, for in one of his letters he said: "It is the truth alone that we desire to know, and oh, what joy there is in discovering it!"

Subtract from our present stock of scientific knowledge the body of truth which he contributed, and applied science as we now know it would be dwarfed, and it is impossible to imagine what would be the backward state of the industries based upon it.

Growing out of the discoveries of Scheele and inspired by his example, two of his pupils, the brothers d'Elhuyar, were the first to isolate and produce metallic tungsten. Were it not for the knowledge gained by these researches in pure science, the very existence of tungsten would be unknown, the tungsten filament lamp would be an impossibility, and the manifold benefits and economies which the public now enjoys as a result of its use, would not be realized. As to the effect upon your own industry, you yourselves can make the best conjecture.

Let me give some other examples of the results which have ultimately followed from scientific researches conducted only for the purpose of discovering new truths or principles.

In the early part of the last century, Hans Christian Oersted, Professor of Natural Philosophy at the University of Copenhagen, made the great discovery that an electric current flowing in a wire could move a magnet; and less than one hundred years ago, Michael Faraday conducting re-

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searches at the Royal Institution in London, discovered that a moving magnet could generate a current of electricity, and that one current could generate another. Joseph Henry, a Princeton professor, and later Secretary of the Smithsonian Institution, independently of Faraday, discovered the laws of current induction. He also made other fundamental contributions to our present stock of scientific knowledge.

This list could be extended at very great length, giving the names of thousands of investigators in the domain of pure science who have contributed knowledge which is indispensable to modern industry and to applied science in all of its branches.

But let us consider the incalculable benefits which the whole world has derived from the knowledge of scientific principles and laws contributed by only three of these great men—Oersted, Faraday, and Henry. If we did not have this knowledge, the electric telegraph would be unknown; neither Bell nor any one else could have invented the telephone; there would be neither dynamo nor motor; your industry would not exist; and we would not at this time be celebrating the great achievement of Edison in the invention of the electric lamp.

I have stated in terms of money some of the debt which we owe to your own workers in applied science; but it would tax the powers of the human mind to estimate the prodigious sums which have been added to the wealth of nations by the contributions of the investigators in the field of pure science seeking solely to discover the truth.

I have spoken of the past, and now let me speak of the future. Countless practical problems now confront mankind which never can be solved by the applied scientist in the present state of scientific knowledge. He must await further fundamental discoveries and new scientific generalizations yet to be furnished by the investigator in pure science. Unless the work of the pure scientist is continued and pushed forward with ever-increasing energy, the achievements of the industrial scientist, in the course of time will become more and more restricted. Already the applied scientists have perfected your dynamos and motors and transformers, so that they are working at 95% of their theoretically perfect efficiency.

While without any increase in our present stock of knowledge in the realm of pure science, the applied scientists would find abundance of profitable work to do, nevertheless in the long run they can proceed no faster than the discoveries of pure science permit. It is of the greatest practical importance, therefore, that we should do everything in our power to encourage and support the work of the pure scientists who are to be found in all of our universities and scientific institutions. The discoveries made by these learned men have no immediate practical value,

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and could not therefore bring to them or to their institutions any pecuniary return. Unlike applied science, pure science cannot support itself. It must depend upon contributions of money from the public, from far-sighted patriotic citizens and men of affairs; from business and commerce and the industries which derive their prosperity or very existence from this field of human endeavor.

The possibilities of research in pure science are boundless, because the resources of nature are without number. Great as are the scientific accomplishments of our day, they are small compared to the possibilities of the future. Two centuries ago, Sir Isaac Newton, the discoverer of the law of gravitation, who ranks perhaps as the foremost scientist the world has ever known, expressed his faith in the infinite possibilities of science in these words: "I seem to have been only like a boy playing on the seashore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."

The scientific developments since the time of Newton so strikingly confirm this vision of the great philosopher that we can feel certain that, if pure science is properly supported, the discoveries of the future will be enormously great in comparison to those which have already been made. Future generations of Americans may look upon us with our present limited knowledge of the forces of nature, as we now regard the American Indian, who cold and shivering in his scanty clothing, was ignorant of the coal at his feet, with its stores of heat and power.

Although seriously hampered and restricted by the lack of funds, American investigators in pure science are pushing forward their work with courage and determination. Among the thousands of problems which occupy their attention, they are attacking the most fundamental of all—the ultimate constitution of matter, the structure of the atom, and the nature of the electron. On the summit of Mount Wilson in California, the astronomers are observing in the sun, and in the stars, and in the nebulae, not only worlds in process of evolution, but what is most astonishing, the evolution of the chemical elements themselves. In laboratories at the base of the Mountain, chemists and physicists are attempting to reproduce with increasing prospects of success, conditions which have been discovered in the depths of the universe. They are splitting the atom into its parts, and their work is filled with the greatest promise. From it I believe science will some day learn how to take the elements apart, and put them together again in new and most remarkable combinations. Already they have found that in the depths of space, hydrogen is being transmuted into helium, oxygen, silicon, and iron. They have

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discovered that the material substance of the faint companion star of Sirius has a density of one ton per cubic inch; while a cubic inch of the material composing another faint star recently studied at Mount Wilson may weigh as much as seven tons.

I believe that in the course of time, if these investigations can be carried forward to success, our applied scientists will be able to provide new structural materials and metallic alloys, lighter or heavier, as may be desired, cheaper and more durable and capable of resisting corrosion. Researches such as these should be multiplied a thousandfold. They will give us the answer to the great problem of drawing upon new sources of energy, and of utilizing those already available with the highest economy and efficiency. No inquiries could go more deeply to the foundations of industral progress than these, and none could hold forth such promise of continued prosperity and of such advancement in all human affairs.

If there were time to do so, I could show the necessity for conducting pure science research not only in those fields which I have already indicated, but I could explain why it is essential to prosecute such researches with the utmost vigor, in every department of science without any exception whatever.

Because it was convenient, I have stated some of the results of science in terms of money. But the value of science can best be measured in terms of human achievement, the mastery of the forces of nature, the elimination of poverty and disease, the prolongation of life, the advancement of learning, the growth of right living and sound thinking and of good understanding among men. Pure science research is indispensable to the attainment of all of these ends. According to the present vision of science, life must no longer be regarded as a struggle among men for a limited store, where one man's gain or one nation's gain must be another's loss. Under the banner of science, we are asked to join with our fellowmen working together in controlling and utilizing the bountiful forces of nature.

"Science," said Pasteur, "is the soul of prosperity of nations and the living source of all progress." American business and commerce and industry and the whole of the American public are being asked to give and to continue to give to pure science research, in our universities and elsewhere, that support which it so greatly needs. For all the benefits which it is conferring upon us, science asks only that we provide its zealous workers with an opportunity to multiply their efforts in our behalf. Upon the answer to this call depends the future prosperity of the nation.

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